IVM Institute for Environmental Studies

Solar lighting for the off-grid BOP in Kenya

An analysis of business models and challenges to growth

M.J. van Asperen

Report
29 September 2010

IVM Institute for Environmental Studies

Thi[redacted]r van Beukerin
It w[redacted]MSc.

VU University Amsterdam

IVM
Institute for Environmental Studies
VU University Amsterdam
De Boelelaan 1087
1081 HV Amsterdam
T +31-20-598 9555
F +31-20-598 9553
E info@ivm.vu.nl

Contents

"We will make electricity so cheap that only the rich will burn candles"
Thomas A. Edison

Summary

1.5 billion people worldwide do not have access to electricity, while energy is an important requirement for development. Households without access to electricity usually rely on kerosene for their lighting needs. Compared to electrical lighting the use of kerosene causes health problems, is less safe, produces a lower quality of light, is more expensive and results in higher CO_2 emissions. As households without access are usually poor they cannot afford large investments to move away from kerosene lighting.

Recently solar lighting products have been introduced that are especially designed and marketed for the poor off-grid population. These solar lanterns and small solar home systems (these products are referred to as pico solar) with retail prices starting at around $15.00 are regarded as an ideal opportunity for these people to move away from kerosene lighting. Nevertheless, the majority of poor off-grid households still depends on kerosene.

For this research 13 interviews were held in Kenya with representatives of companies and NGO's offering pico solar products. Several challenges were identified that the interviewees face while growing their operations. The four most important are affordability, poor quality products, consumer awareness and distribution.

The targeted customers for pico solar products are the extremely poor, also referred to as the Base or Bottom of the Pyramid (BOP). Offering products to BOP consumers requires an approach adapted to the harsh conditions of the BOP environment. This calls for business model innovations. This research describes the way in which companies and NGO's have designed and adapted their business models to the BOP conditions.

1 Introduction

1.1 Problem statement

1,5 billion people worldwide currently do not have access to grid electricity (IEA, 2009). For their lighting needs they mainly rely on burning kerosene. The majority of the population in Eastern Africa lives in poverty. Especially in the rural areas there is no or limited access to the electricity grid. Due to the lack of access to modern energy sources the population of rural Eastern Africa largely depends on energy resources of lower quality such as wood and charcoal for cooking and kerosene for lighting.

Solar lighting has come up as a promising alternative to burning kerosene for lighting in developing countries around the world. Several companies have developed products that harvest solar energy - that is often widely available in developing countries – by converting it into electricity using a PV panel. This electricity can then be used for lighting needs after dark. Although promising, the industry is still in its infancy and the number of people using solar lighting products is still a fraction of the amount of people relying on their old customs of burning kerosene. This means there is still an enormous untapped market potential that can be served, but doing so is not an easy task as serving poor consumers comes with difficulties.

1.2 Link to the IS Academy

The IS Academy is a cooperation program between the Dutch Ministry of Foreign Affairs (DGIS) and knowledge institutions which was started in 2005. Within the IS Academy a project has been started called “Greening the African Energy Ladder”. This project studies renewable energy in Eastern Africa and the linkage between energy access and poverty eradication and is closely linked to the goal set by DGIS in 2004 to provide access to modern energy to 10 million people by 2015. The project outline is laid out in a scoping paper (IVM, 2009) and the project started in 2010. The focal countries of the project are Kenya, Mozambique and Rwanda. The research is subdivided into three themes that each study the renewable energy potential in Eastern Africa from different research perspectives:

- **Theme 1: Entrepreneurial perspective**. The main objective is to identify business opportunities that enable households to escape poverty through the use of commercially viable renewable energy technologies.
- **Theme 2: Household perspective**. The first main objective is to analyze the adoption of renewable energy technologies by households and their impact on welfare. The second is to develop and empirically test a model for household energy demand including potential renewable and non-renewable energy substitution possibilities.
- **Theme 3: Institutional perspective**. The main objective is to study the adoption and diffusion of renewable energy technologies from the perspective of innovation system theory.

This research paper falls within the scope of theme 1 and focuses on substituting the use of kerosene lighting products in Kenya with solar PV from an entrepreneurial perspective.

1.3 Research question

Given the benefits solar lighting could bring to the poor in Kenya and the availability of suitable and designed to meet the needs of the poor the following research question was developed:

What are the challenges enterprises face when selling off-grid solar lighting products to low-income households in Kenya and how can these challenges be confronted?

The main research question is subdivided into four sub questions, each touching upon different aspects.

What challenges do manufacturers, distributors and NGO's face in the market for off-grid solar lighting products in Kenya?

What are the characteristics of the different kind of business models used by distributors and manufacturers of solar lanterns and small solar home systems?

What business model innovations are used to confront these challenges?

What role can (government) institutions play in confronting these challenges?

By answering these questions this research hopes to give a good insight into the market for off-grid solar lighting products targeted at poor households in Kenya. It aims to identify barriers to firm growth for entrepreneurs and subsequently for the whole market. It furthermore tries to identify potential actions that can be taken to overcome these barriers.

1.4 Structure of the report

Following this introductory chapter we will focus on the background of the research in chapter 2. Chapter 3 will cover the management literature within which the research is placed, discussing business model literature and Base of the Pyramid approach for poverty alleviation. The methodology used for the fieldwork component of the research will be discussed in chapter 4. Chapter 5 will present the fieldwork results as well as a discussion of these results. We will end with recommendations in chapter 7.

2 Background

2.1 Introduction

In this chapter first a brief summary will be given about the linkage between energy access, sustainable development and the Millennium Development Goals. Thereafter we will focus on the various benefits of solar lighting over kerosene lighting. This is followed by a section on the country of Kenya and its energy use. Finally we will go into the scope and description of the products studied in this research.

2.2 Energy access and the MDG's

The Millennium Development Goals (MDG's) were set out by the United Nations in 2000 and set clear development goals classified in the following categories:

- End Poverty and Hunger
- Universal Education
- Gender Equality
- Child Health
- Maternal Health
- Combat HIV/AIDS
- Environmental Sustainability
- Global Partnership

The goals are subdivided into 21 targets and there is a series if measurable indicators for each target. Access to modern energy is believed to be especially linked to the first goal, ending poverty and hunger, but will also have the ability to contribute to the goals of universal education, child health, maternal health and environmental sustainability. An overview of the benefits of access to modern energy services related to the 8 MDG's is included in appendix A.

2.3 Study location

Kenya is a country of 38.5 million inhabitants located on the equator in Eastern Africa covering 580,000 square kilometres. The country borders the Indian Ocean in the southwest and is further bordered by the countries of Somalia, Ethiopia, Sudan, Uganda and Tanzania.

Figure 1: Map of Kenya. (retrieved from http://tapiwa.files.wordpress.com/2008/08/kenya2.jpg)

The capital, Nairobi inhabits 6 million people and has – like many other capitals in developing countries – grown explosively over the last decades. With a GDP per capita of $640 Kenya is one of the poorest countries in the world. Whereas Kenya has got one of the most advanced markets for solar energy in SSA only a small fraction of the market opportunity of the market for solar lanterns and small solar home systems has been currently captured. As shown in table 1 kerosene is by far the most commonly used source of lighting in Kenya.

Source of lighting	**Percentage**
Kerosene	70.2
Collected firewood	13.2
Electricity	7.8
Purchased firewood	3.9
Solar	2.4
Grass	1.0
Dry cells torch	0.5

Table 1: Lighting sources in Kenya (adapted from Nassiuma, 2005)

The fact that so many people still rely on kerosene lanterns for their lighting needs implies that there is a large opportunity for solar lighting products to replace these lanterns.

2.3.1 Electricity in Kenya

The main reason for the dependence on kerosene for lighting needs lies in the fact that Kenya has a low rate of electrification. As shown in table 2, 15% of the total population currently access to electricity. As this is the average for the country, this figure drops to 5% for people living in the rural areas.

	2008 Electrification rate %			Population without electricity
	Total	Urban	Rural	Millions
Kenya	15	51.3	5	32.8

Table 2: Electrification rate of Kenya. Source: International Energy Agency Database, IEA.

Table 3 gives an overview of the different technologies of electricity generation and the number of GWh's generated over the period 2004-2008. A large part of electricity delivered through the Kenyan electricity grid is generated from renewable sources. Large hydro and geo thermal generation make up the largest part of these renewable sources.

	Hydro[1]	Thermal oil	Geo thermal	Co-generation
2004-2008	54.71%	28.02%	17.20%	0.06%

Table 3: Electricity generation by source in GWh (adapted from Kenya Bureau of Statistics, 2009)

The amount of electricity generated by on grid solar PV is so low in comparison to other generation technologies that it is not included in the figures in electricity generation of the Kenya Bureau of Statistics. The same is true for off-grid solar electricity generation as used for off-grid lighting purposes.

[1] Includes imports from Uganda and Tanzania.

2.3.2 Future outlook

In order to increase the electrification rate of the country the Kenyan Energy Act of 2006 sets out rules, regulations and responsibilities with regards to energy focusing on electrical energy and petroleum and natural gas. It also includes a part on renewable energy stating that the "Minister shall promote the development and use of renewable energy technologies, including, but not limited to biomass, biodiesel, bioethanol, charcoal, fuelwood, solar, wind, tidal waves, hydropower, biogas and municipal waste" (Energy Act, 2006). Concrete measures are not part of the Energy Act.

In 2008 the long-term development plan for Kenya was drawn up called Vision 2030. This plan focuses on several areas that could fuel the development of Kenya over the period 2008 to 2030. Energy generation and energy access in particular are topics that deserve attention in the plan. While the current electrification rate is still very low the Kenyan authorities have ambitious plans for further electrification of the rural areas. The main governmental body to take on this task is the Kenyan Rural Electrification Authority (REA), established in 2006. Based on Vision 2030 the REA has drawn up a Strategic Plan for the Period 2008-2012 (Renewable Energy Authority, 2008). The plan includes targets for rural electricity connectivity rates as summarized in table 4.

Phase	Period	Proportion of Rural Population with Electricity
	2008	10%
Phase I	2008 – 2012	22%
Phase II	2013 – 2022	65%
Phase III	2023 - 2030	100%

Table 4: Rural electricity connectivity rates. (Rural Electrification Authority, 2008)

While these targets are very ambitious it needs to be seen whether they are achievable as experience shows that rural electrification programs often do not meet up to their high expectations, while in many African countries rural electrification the pace of rural electrification is even lower than rural population growth, leading to a decline in the percentage of electrification (Barnes and Foley, 2004). Because of the dispersed population the costs of rural electrification in Kenya are very high. The average costs of connecting a rural household to the grid are seven times the national per-capita income (REN21, 2008). The Rural Electrification Authority looks at both national grid extension and off-grid projects for rural electrification. These off-grid projects get their electricity supplied by diesel generators, mini hydro installations, solar PV and biomass (Rural Electrification Authority, 2008). It is currently not clear what proportion of the rural electrification each of these options will cover.

2.3.3 Solar potential

Kenya is blessed with high levels of insolation throughout the whole country. Regional and seasonal differences taken into account the annual averages of solar energy are well over 5 KWh/m^2/day (NASA, 2010; GTZ, 2009). When compared to Europe these values can only be found at some southern European locations. Insolation maps of Kenya and Europe are presented in figure 2 and 3.

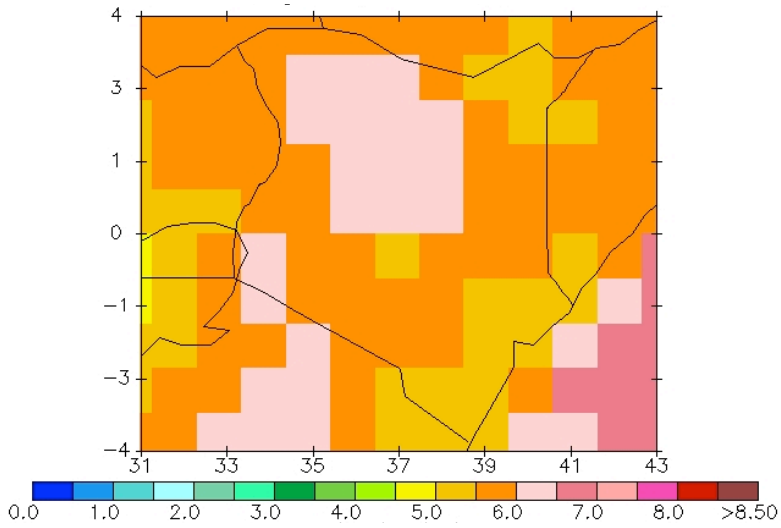

Figure 2: Annual average insolation in Kenya kWh/m^2/day from 1983 - 2005 (NASA, 2010)

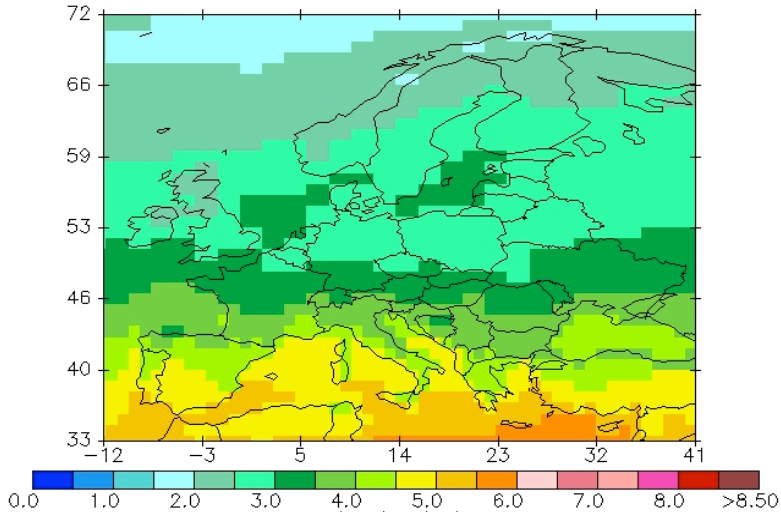

Figure 2: Annual average insolation in Europe kWh/m^2/day from 1983 - 2005 (NASA, 2010)

The large solar potential in Kenya has not remained unnoticed. Kenya has a long experience in solar energy with the first PV panels being installed in the 1970's. It especially has a well developed market for solar home systems (SHS) with a large choice of system sizes and specifications which are mainly bought on a cash basis. In early 2000 a total of around 150,000 systems were installed making Kenya the developing country with the highest share of SHS installed per capita at 2.56%, after Zimbabwe at 3,42% (Nieuwenhout, van Dijk et.al., 2001). The majority of systems have been and still are sold at commercial rates in Kenya and the market has developed with little to no donor support (Wamukonya, 2007).

2.4 Kerosene and solar lighting

When compared to fuel based lighting technologies like kerosene lanterns the use of solar lighting products comes with several advantages. By switching to solar households will be able to enjoy improved health, safety and quality of lighting. Furthermore they will save money and time and eventually reduce their CO_2 emissions.

Health: Burning kerosene causes severe indoor air pollution. This is due to the fumes produced by the burning of kerosene and made worse by the limited amount of ventilation usually present in the houses of families using kerosene. The air pollution causes respiratory diseases, especially affecting women and children as they spend more time indoors then men. Obeng et. al. (2008) found that families using solar lighting are less affected by indoor smoke then families using kerosene. Measurements of indoor air quality of households using kerosene lanterns executed by Peon et.al. (2005) found concentrations of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) that by far exceeded the safe maximum concentration levels set by the Environmental Protection Agency. Furthermore average carbon monoxide concentrations were found to be so high it would cause a reduction in the amount of oxygen delivered to the body's organs, with higher concentrations being lethal.

Safety: Kerosene is a highly inflammable liquid fuel. Burning kerosene for lighting purposes causes fire hazards. A burning kerosene lantern that is tipped over can easily burn down a house. In an impact study of the use of LED lighting Johnstone (2009) found that people using LED lighting products perceive them to be safer than kerosene lamps.

Quality of light: Solar lighting products produce light of a better quality then kerosene lanterns. The lumen output of a solar lantern with a 1W LED is 6 times higher than that of a kerosene lantern (Irvine-Halliday, 2005). Better quality of light can create – besides a higher quality of life – an improved study environment for children and improved opportunities for indoor income generating activities like producing handicrafts etc.

Potential cost savings: The initial purchase price of a kerosene lantern is significantly lower than that of a solar lantern or small SHS. A solar lantern or small SHS on the other hand has no operating costs, except for the purchase of a new battery after several years of operation, compared to the purchase of kerosene that is required for the operation of a kerosene lantern. Peon et al. (2005) have calculated that the annualized costs of a solar lighting system of $100.00 are $ 17.88 per year over 10 years using a life cycle costing analysis. This is significantly lower than the $60.00 that would annually be spent on kerosene for the same amount of hours of light. With these figures the payback period of the solar lighting system is under two years when compared to kerosene lighting.

Time savings: When in rural areas kerosene is not available nearby people need to spend time in order to purchase kerosene in distant vending locations. Using solar lighting products has the ability to free up this time to use it for other (income generating) activities. To the authors knowledge there has not been any research conducted towards the size of time savings that could result from switching from kerosene to solar lighting. This largely depends one the availability of kerosene.

Environment: Besides the toxic gases that are released by burning kerosene mentioned in paragraph in the section on health, kerosene burning also causes carbon dioxide (CO_2) emissions that contribute to the greenhouse effect and global warming. Worldwide lighting fuel consumption is equivalent to 1.3 million barrels of oil per day, resulting in carbon dioxide emissions of approximately 190 million tons per year (Adkins et al., 2010). Burning one kerosene lantern for one year approximately causes emissions of 133.9 kilograms of CO_2 (Peon et.al., 2005). These emissions can be prevented by replacing kerosene lanterns with solar lanterns or small solar home systems.

2.4.1 Product scope

Solar systems exist in many sizes, ranging from a small solar lantern with an integrated battery and solar panel to large grid connected systems that produce several kW's of electricity. In this research we focus on products that serve the lighting needs of the Base of the Pyramid (BOP) consumers that do not or have very limited access to the electricity grid. These products fall into

the commonly used categories of solar lanterns (picture X) and small solar home systems (picture X). GTZ (2010) refers to these products as pico solar and this term will be used throughout this paper.

2.5 Conclusion

Kenya currently has a very low electrification rate. There are ambitious plans for rural electrification, but it is questionable whether the targets laid out in these plans can realistically be achieved. As Kenya receives a lot of solar radiation solar lighting is an interesting alternative to kerosene lighting in the absence of grid connections with several benefits.

3 Literature review

3.1 Introduction

This chapter will focus on two bodies of academic literature, the Bottom of the Pyramid approach for poverty alleviation and business models.

3.2 The Bottom of the Pyramid approach for business and poverty alleviation

The target customer for pico solar products is the poor mainly rural population of Kenya that does not have access to the electricity grid. The income of these people is generally low and this customer segment is often neglected by larger corporations. These people with extremely low incomes are generally referred to as the Bottom or Base of the Pyramid (BOP). This terminology has become widely adopted since the publication in 2006 of the bestselling book "The Fortune at the Bottom of the Pyramid" by C.K. Prahalad. The BOP literature that has evolved over the last decade has focuses on business innovations in serving the poor worldwide and while doing so improving their living conditions.

Traditionally aid programs that are based on donations have been an important driver in poverty alleviation, but are unfortunately not economically sustainable. Because of capital constraints these programs always have a limited scope and therefore a limited amount of people they are able to serve. Alternatively, market-based approaches of poverty alleviation can be economically sustainable. The BOP perspective is such a market-based approach.

There are several definitions of who actually make up the BOP. Prahalad and Hart (2002) classify the BOP as the 4 billion people who have a per capita income of below $1,500, as depicted in figure 4.

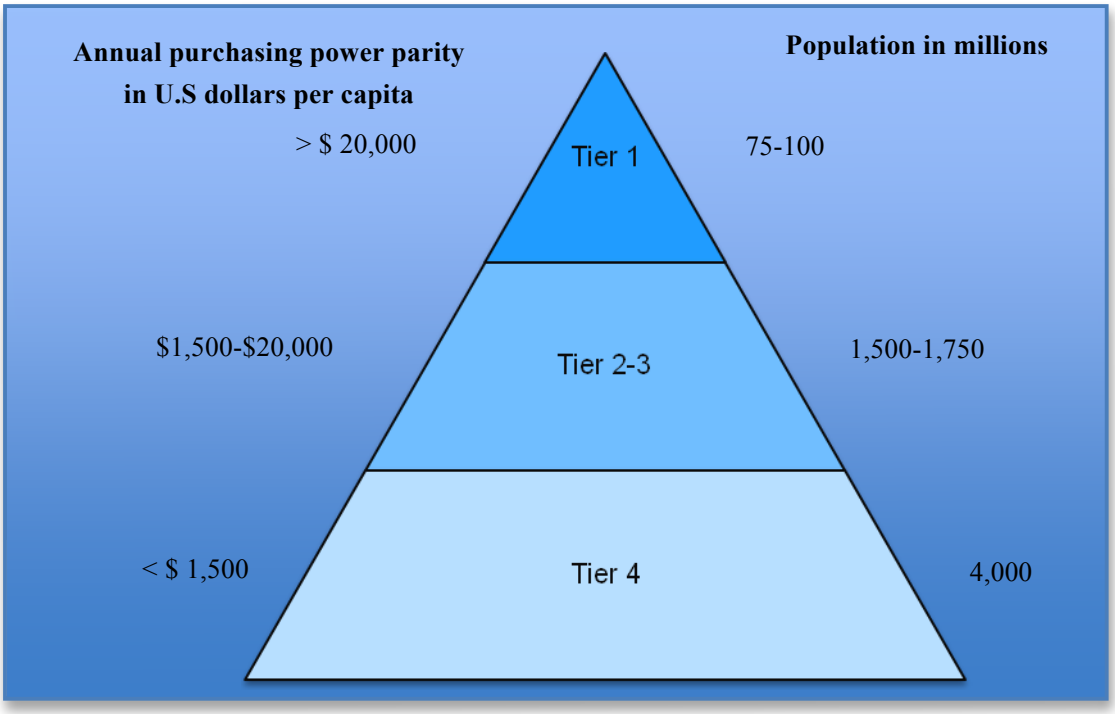

Figure 4: The economic pyramid. Adapted from Prahalad & Hart (2002).

Prahalad (2004) speaks about more than 4 billion people who live on less than $2 a day. The World Resources Institute (2007) includes all those with incomes below $3,000 in local purchasing power in the BOP, while this BOP is further subdivided into six income segments of BOP500, BOP1000, BOP 1500, etc. London (2007) has a distinct definition of who makes up the BOP without a reference to income earned:

> The base of the pyramid is a term that represents the poor at the base of the global socio-economic ladder, who primarily transact in an informal market economy.

Two different orientations can be distinguished in BOP enterprises. Rangan et. al. (2007) termed them as "BOP as consumer" and BOP as producer". The first sells its goods or services to BOP consumers, while the latter sources its products from BOP producers. Both are believed to improve the standards of living of the BOP through their operations. The BOP perspective is not meant to be seen as the best way of alleviating poverty in the developing world, but can complement other initiatives run by private, non-profit, development or government actors.

Several authors have been critical about the BOP approach. Leonard (2007) states that the positive poverty alleviation characteristics of BOP initiatives have so far just been outlined in anecdotes included in the BOP literature, focusing on the benefits accruing to certain BOP individuals. Jaiswal (2007) argues that the success stories in the BOP literature are about fast-growing economies or countries with a higher per-capita income, not the least developing countries. Karnani (2006) is also very critical about the ability of poverty alleviation of the BOP proposition:

> The BOP proposition is indeed too good to be true. It is seductively appealing, but it is riddled with fallacies. There is neither glory nor fortune at the bottom of the pyramid – it is all mirage.

The UNDP has identified five constraints that make doing business at the BOP difficult, risky and expensive (UNDP, 2008). These constraints are:

Limited market information. Companies often have too little information about the poor at the BOP. They lack knowledge about what the consumer preferences, what they can afford and in what way the poor can contribute to their business as producers or employees.

Ineffective regulatory environments. The BOP markets lack the right regulatory framework for companies to operate in. Therefore the opportunities and protections that stem out of a well functioning legal system are missing for both people as companies.

Inadequate physical infrastructure. The absence or poor quality of roads and the supporting infrastructure constrains transportation. Clean water, electricity and proper sanitation are also often not available.

Missing knowledge and skills. People at the BOP have often received little education and lack proper information. Therefore consumers may not be familiar with the use and benefits of certain products or may not be able to use these products effectively. Poor suppliers, distributors and retailers on the other hand lack the skills and knowledge needed to deliver products and services of high quality consistently, on time and for a reasonable price.

Restricted access to financial products and services. Poor BOP producers and consumers are not able to finance investments or large purchases because they are unable to access credit at reasonable costs. As they also lack insurance they are unable to protect their limited assets and income against hazards like theft, natural disasters or illness. In the absence of regular banking services, their financing is insecure and expensive.

In order to do business at the BOP companies need to develop innovative business models when catering to BOP customers because of these difficult business conditions. The next section will look into the characteristics of business models and business model literature.

3.3 Business models

The term business model is relatively new in the academic literature and found its peak at the beginning of this century during the Internet boom (Osterwalder, 2004). While at first it was mainly used in correlation with new online businesses, also referred to as e-business, the term has thereafter made its way into the off-line business environment.

But what does the term business model actually mean? First of all Stähler (2002) reminds us that a model is always a simplification of the complex reality. Linder and Cantrell (2000) use a definition of a business model as the "organization's core for creating value". This core is not a static state, but should be continuously renewed to match the dynamism in the markets in order to have the company succeed. Petrovic, Kittl et al. (2001) similarly describe a business model as "the logic of a 'business system' for creating value that lies behind the actual processes". The business model describes why the different business processes are designed the way they are. Shafer et al. (2005) after studying several earlier definitions in the literature from 1998 to 2003 come up with a slightly more extensive definition stating that a business model is a representation of a firm's underlying core logic and strategic choices for creating and capturing value within a value network. Afuah and Tucci (2003) argue that a business model should incorporate answers to several questions: What is the value offered to customers, which customers to provide this value to, how should the value be priced, who will be charged for it, what are the best strategies to undertake to provide the value and how to sustain the advantages from providing the value. This business model approach focuses on value creation and takes into account through which actors this value is created.

After peaking during the Internet boom the business model concept has also been introduced in the literature on poverty alleviation in developing countries. Karamchandani et.al. (2009) argue that business models that work well in serving affluent and middle income customers are unlikely to function in low-income markets. We should thus study and design business models for low-income markets in separation from those used in the higher segment markets. Hereby a linkage between business model theory and BOP theory is created.

When studying a firm's business model it is in the first place necessary to investigate out of which components the business model is made up. Stähler (2002) constructs a framework that consists of four components. Firstly, there is the value proposition. This component describes what value a customer or partner to the business receives from the business. It answers the question of what value the business creates for its stakeholders. Secondly, the product or service the company offers is the link to the customer. This means the business model should include a description of the product(s) and/or service(s) is offering its customers. It answers the question of what the firm actually sells. Thirdly, the business model describes in what way value is actually created. This so called architecture of the value creation describes the value chain and the various actors involved including their roles. It answers the question of how value is created and in what configuration this occurs. Finally, a revenue model should be included in the business model. It describes the basis and the sources of income for the firm and thus answers the question of how a company earns money.

Using Stähler's business model components as a starting point Osterwalder (2004) builds a framework, which consists of four areas a business model has to address, as depicted in table X.

Business model area	Questions to address
Product	What business the company is in, the products and the value propositions offered to the market
Customer interface	Who the company's target customers are, how it delivers products and services to these customers and how it builds a strong relationships with them
Infrastructure management	How the company efficiently performs infrastructural or logistical issues, with whom, and as what kind of network enterprise
Financial aspects	What is the revenue model, the cost structure and the business model's sustainability

Table 4: Osterwalder's business model framework (based on Osterwalder 2004)

In this research we will use this framework to analyze the business model characteristics of pico solar companies in Kenya as it provides a clear distinction of business model areas to address in the analysis.

3.4 Conclusion

The BOP approach is a for companies to do business while in the meantime improving the living conditions of the poorest people, while some authors are critical about whether the BOP approach actually contributes to poverty alleviation. There are several constraints that make doing business at the BOP harder. Business model innovations should take these constraints into account.

4 Methodology

4.1 Introduction

This chapter discusses the methodology of the research. It addresses the geographical location of research, the type of fieldwork that was conducted and the method of data analysis. It furthermore covers the limitations connected to the research methodology and its execution.

4.2 Fieldwork

The geographical scope of this research is the whole country of Kenya. The fieldwork was conducted form April 29th to May 27th 2010 in the capital, Nairobi. This location was chosen, because most companies selling in off-grid solar lighting products in Kenya have their head offices in Nairobi, which would be convenient for interviewing. Furthermore the Lighting Africa conference of 2010 was held in Nairobi from July 18th to 20th, where a large number of companies, researchers, NGO's and government officials working in off-grid solar lighting were present.

4.2.1 Nairobi

During a four-week fieldwork in Kenya several interviews were conducted with suppliers and distributors of small solar lighting products like solar lanterns and small solar home systems as well as NGO's working with these products. Interviewees were selected through Internet research and personal contacts. In selecting the interviewees it was tried to include representatives of different organizations based on type of organization, size, product price and area of operation. Hereby a diversified interviewee base was established.

4.2.2 Lighting Africa Conference

The Lighting Africa conference was held in Nairobi, Kenya from July 18th to 20th 2010. The conference is an initiative of the International Financial Cooperation (IFC) and the World Bank and is "a key platform for the promotion and development of affordable off-grid lighting for African consumers". The author has attended the conference, where several workshops and sessions were held focusing on different aspects of off-grid solar lighting in Africa. During the conference several attendants were interviewed and after the conference an interview was held with the technical manager of Lighting Africa.

4.2.3 Semi-structured interviews

The interviews were conducted using a general outline with open questions in order to cover all subjects while leaving enough room for a more open conversation than when using a questionnaire. The outline is subdivided into three sections. The first section covers general characteristics of the organization. The second section covers the way the organization operates in order to study the characteristics of its business model. The third section addresses the challenges the organization faces in conducting and growing its business. A copy of the outline can be found in appendix A.

4.3 Data analysis

After returning from Kenya all interviews that were recorded during the fieldwork were transcribed. A table was developed to orderly classify the interview outcomes on the different subjects addressed in the interviews. This table will be introduced in section 5.1. The next step was to identify all challenges mentioned by the interviewees in the transcripts. The challenges and the number of times they were mentioned during the interviews were summarized in figure X. After distilling all information necessary for the table and covering business challenges the transcripts were further analysed for information relevant to the research questions.

4.4 Limitations

Due to time constraints it was only possible to interview a limited number of people in Kenya. The majority of interviewees were from organizations that were also present at the Lighting Africa conference. Those who were interviewed before the conference took place were contacted through personal contacts or their online presence. Therefore an important segment of the market is not covered by the interviews, namely the companies that import unbranded, low quality products. This is also a part of the market that Lighting Africa tries to map out and get in touch with as came out of the interview with the IFC, one of the organizations behind the Lighting Africa initiative.

Some challenges were included in the interview outline but all interviewees were asked to mention other challenges themselves. This could lead to an overrepresentation of the challenges that were included in the outline. in the number of times they are mentioned by the interviewees.

By only studying the supply side of the market for pico solar products, demand side challenges are not included in the market analysis.

5 Results and conclusions

5.1 Introduction

This section addresses the findings that came out of the semi-structured interviews and the attendance of the Lighting Africa conference. We will first cover the identified business challenges and thereafter the describe the characteristics of the different business models encountered. Furthermore we will discuss findings on carbon credit financing. Table X gives an overview of the main characteristics of the interviewees including the interviewee code that will be used throughout this research.

5.2 Business challenges

In the outline of the semi-structured interview (Appendix B), that was held with 13 different market players several challenges were included that were identified in the preliminary literature review. There challenges are:

- Poor quality products
- Lack of customers who are able to afford products
- Lack of access to credit to upscale company
- Difficulties in distribution
- Lack of potential retailers

Interviewees were confronted with these potential challenges and were asked whether they perceived them as challenges for their company. Furthermore, interviewees were free to address challenges that were not mentioned. Table 6 shows the challenges and the interviewees that mentioned these challenges. Figure 5 shows the challenges and the number of times each challenge was mentioned.

Interviewee	001	002	003	004	005	006	007	008	009	010	011	012	013
Affordability	+		+		+		+		+	+	+	+	+
Poor quality products	+		+	+			+	+	+			+	
Awareness	+	+	+		+						+	+	
Distribution			+				+			+	+	+	
Too high expectations	+							+	+				
Access to finance						+	+						+
Donor projects				+	+								
Company staff					+				+				
Retailers not stocking		+				+							
Lack of quality ratings					+								
Unclear import regulations												+	

Table 6: Interviewees and challenges mentioned

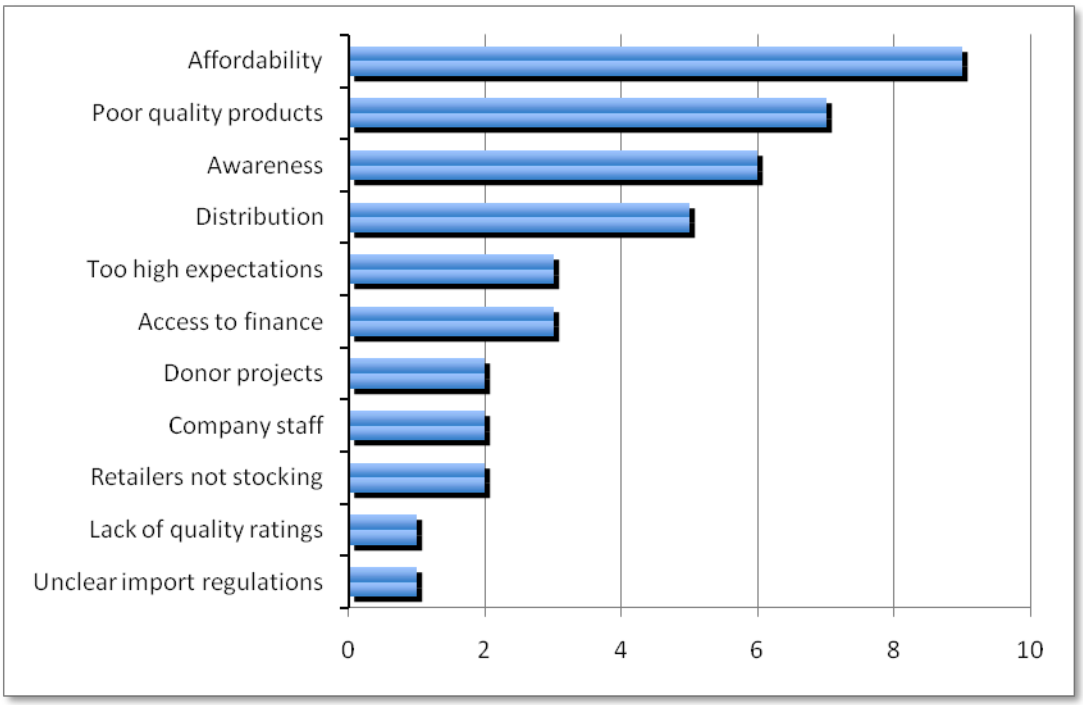

Figure 5. Challenges and number of times mentioned by interviewees

The four challenges that were mentioned most will be discussed in sections 5.2.1 to 5.2.4. The other seven challenges will be addressed in 5.2.5.

5.2.1 Affordability

Nine interviewees mentioned affordability as a challenge. This is in line with the fifth constraint of doing business at the BOP mentioned in 3.2. By affordability we mean the inability of consumers to buy a pico solar product of the interviewed company at the regular, unsubsidized market price. The fact that the products are not affordable for a significant part of the Kenyan population is a consequence of the very low incomes of the target consumer population for whom these products are intentionally designed. As interviewee 001 puts it: "The upfront costs of (pico) solar products are high and most of the customers in Kenya don't have the money." Interviewee 003 mentioned that "at the moment there isn't an affordable product on the market yet, … but with prices coming down there will be a point where we'll be able to sell hundreds of thousands of products." 013: "If the price would be lower it would be easier to sell."

While the majority of interviewees acknowledge affordability as a challenge some do not agree. Interviewee 008: "I have always believed that every home that can afford a meal on the table can afford these products. Many homes have 3 mobile phones, whose market value is more than $25, which is the price of a small solar lantern." This implies that even while households are able to afford a solar lantern they prefer to spend their money on other items. Interviewee 006 states that its products are on the long run cheaper to operate than a kerosene lantern: " I don't think affordability is the problem. The problem is access to the money. A rural household spends about $48 a year on kerosene for one light and our lantern is sold for $25 and will last for 3 years. So clearly our lantern is affordable."

This would imply that the affordability issue could be confronted by cooperating with micro financial institutions (MFI's) that offer customers the opportunity to pay in instalments. 8 Interviewees already cooperate with MFI's and 2 say to be looking into this. But even MFI's have their minimum amounts for the loans they sign. Interviewee 006 has experienced this and is

looking into ways to overcome this: "$25 is a too small amount for an MFI to justify to manage that loan. So we try to find different ways like bundling that loan with other loans. If a client is taking a loan for a car or a machine you can add on $25 to that loan." Interviewee 009 works with an MFI that has a different approach: "MFI's give us a platform to reach their members. They give us like 100 people that want to buy our product and they give them the loans. … These are all community based groups." By bundling the loans of members of community based groups the total sum of the loan rises making it profitable for an MFI to get involved.

5.2.2 Poor quality products

This challenge was acknowledged by seven interviewees. The challenge of poor quality products refers to poor quality products that are sold in the market by other company's than the interviewees that hurt the reputation of solar. This harmed reputation then makes it more difficult to convince potential customers of the quality and usefulness of the offered product(s). 006: "When a customer buys a product that fails they tell all their neighbours so it ends up destroying the market." Interviewee 008 gave an example of a company who's products it was selling seven years ago until other companies started "copycatting". Because these products sold at half the price, but weren't as good as the original the company died a "natural death". Interviewee 004 experienced poor quality and lack of after sales support of competitors: "… a lot of times you find that a company went into an area and dropped a certain product, like a solar system and after some time it breaks down and there's nobody to fix it. The fact that poor quality products are not prevented from being sold is linked to the second constraint of doing business at the BOP: ineffective regulatory environments.

A solution to the problem of poor quality products destroying the market could be to develop quality standards that prevent poor quality to be sold in the Kenya. Interviewee 005 mentions that the industry is currently focusing on the wrong method of measuring system performance. The quality rating system that is being developed at the moment and the Kenya Bureau of Standards test the amount of Watts of a product or system. Interviewee 005 opposes these practices: "Everybody uses Watt, but it only says something about what goes into the lamp. It doesn't say anything about what comes out. Watts are irrelevant. What you need to know is the amount of lumen[2] produced". Even with the proper standards in place there is still room for products entering the country without being tested. As the IFC mentions: "We are really concerned about people getting a container full of unbranded solar products in and just sell them without being noticed. It's hard to find who they are."

5.2.3 Consumer awareness

As pico solar products have not been marketed and sold on a large scale throughout Kenya yet, consumer awareness was believed to be a challenge by six of the interviewees. Interviewee 003 states that people are not aware of the existence of lower priced solar products: "In the past we haven't had 1 to 5 Watt solar panels, just 20 Watt and bigger. So most people in Kenya have the perception that solar is for rich people."

This challenge is closely linked to the fourth constraint of doing business at the BOP covered in 3.2: missing knowledge and skills. Promotional activities increase the awareness about the products the interviewees each offer. Examples of promotional activities are road shows, where products are demonstrated, radio commercials and newspaper advertisements. While by doing so

[2] Lumen is the measurement unit of the International System of Units of the amount of light perceived by the human eye. The watt to lumen conversion rate depends on the type of lighting device that is used so lumen is a better indicator of lighting performance than watt. For this reason the European Union has adopted the that Eco-Design Directive for Energy-using Products, which prescribes that the labelling on packaging of lighting products should state the amount of lumen instead of watts.

each organization promotes its own products. Awareness creation of a new product segment i.e. pico solar products can be seen as a common good and companies investing in awareness campaigns need to share the benefits of these campaigns with their competitors who thereby free ride on the other's investment. This calls for entities like governments or NGO's, that operate on a not for profit basis to step in.

5.2.4 Distribution

An inadequate physical infrastructure was the third constraint of doing business at the BOP mentioned in 3.3. The challenge in distribution refers to the difficulties of getting a company's products delivered to the end consumer and was perceived as a challenge by five interviewees. 003: "I would say this is probably the most important factor of success for all the companies coming up, trying to do this. Product quality, affordability and marketing are really important, but probably the hardest obstacle is going to be distribution". Interviewee 011 stated that his organization doesn't deliver its products to certain areas because it is too costly to get the cars to those areas. Interviewee 007 mentioned that it tried to distribute its products through supermarkets, but had to stop doing so because the supermarkets didn't want to stock the products anymore because of low sales volumes.

The distribution challenge stems from the fact that the rural population of Kenya lives dispersed throughout the country and roads tend to be in bad condition especially in the rural areas. Some interviewees take care of their own distribution, while others have outsourced this. Interviewee 001 uses a courier service whose network covers the whole country. Interviewee 003 has just moved into the Kenyan market and has outsourced its distribution to a partner that already has its whole distribution network in place: "They have 12 depots and from there they distribute to their outlets so we'll have hundreds of outlets in Kenya soon."

5.2.5 Other challenges

Too high expectations: Three interviewees mentioned that they experience that consumers tend to have too high expectations about the performance of their products. This challenge is linked to the fourth constraint mentioned in 3.3 of missing knowledge and skills that is typical for BOP markets This especially holds for small SHS's as buyers try to hook up more electrical equipment to the system than the capacity of the system allows for. Interviewee 009 gives the example of households trying to run their television on a small solar system and being disappointed when this doesn't work. Interviewee 008 ties argues that too high expectations are often linked to a lack of responsibility for the system within a household: "People don't always use the system the way they should because it's nobody's responsibility. It's a family thing and often never gives them what they bought it for".

Access to finance: Some companies have difficulties in attracting credit or a loan to upscale their company. This challenge was named access to finance. Interviewee 006 states: "It is hard to find a loan or investors and if you do find a loan interest rates are very high". Interviewee 013 also encounters difficulties in financing the parts they need to buy in order to assemble finished products ready for sale and puts it very straightforward: "accessing loans is hard."

Donor projects: Market disturbance by donor projects was mentioned by two interviewees. 004 stated that it is much more difficult to sell its products in areas where donors have been or are currently implementing lighting projects. Interviewee 005 has his doubts about the intentions of international donor organizations and the World Bank in particular, stating that the World Bank works with a hidden agenda: " Developed countries need resources from other countries and used to do that through colonies. After World War II it was not accepted anymore to have colonies, so a new model had to be developed. That was the World Bank model". The interviewee argued that

the true mission of this model is to get developing countries into debt and refers to the book Confessions of an Economic Hit Man[3].

Company staff: Attracting and retaining good quality staff was mentioned twice as a challenge. Interviewee 009: "We've got a big challenge which is retaining our company staff. As entry costs for the solar market are not that high, what happens is you train people from university and they quickly start their own little business". Interviewee 005: "The biggest challenge is actually human resources … you have to perform and therefore you need good people."

Retailers not stocking: Two interviewees mentioned that retailers tend to be unwilling to stock enough products. This causes potential customers to be unable to buy the products at times when it is out of stock. 002: "Convincing shopkeepers to stock our products is an issue. It's a new category, so they don't know it. The consumers don't know it so as long as they don't get a pull from the consumers they are not willing to stock it." Interviewee 006 has experienced that even when there is demand this is sometimes not high enough for retailers to stock products: " Even if the margins are there, but the customer doesn't buy it enough the retailer spends its money on something that moves quicker. The challenge is that there are other products that have a more attractive proposition."

Lack of quality ratings: One interviewee (005) mentioned that there are currently no standardized quality ratings available that inform consumers about the specifications and performance of pico solar products. Because of this, the interviewee stated consumers are not able to make a good comparison between different products and tend to choose for the cheaper option that in many cases doesn't deliver the desired or best performance. This challenge is closely linked to ineffective regulatory environments that characterise BOP markets as mentioned in 3.3.

Unclear import regulations: This is another consequence of an ineffective regulatory environment Interviewee 012 mentioned that there is a lot of uncertainty about duties and taxes applicable to pico solar products. "Panels are duty free, but solar lanterns fall into a grey area, because these products are thus far not well classified". Therefore it can occur that one shipment of solar lanterns can be imported without having to pay duties, while for the next shipment duties have to be paid.

5.3 Pico solar business models

In the semi-structured interviews the interviewees were asked to describe their business models. Some did this much more extensively than others. In the latter case more information was obtained by asking additional and more specified questions, that were not included in the outline of the semi structured interview. The results will be discussed using Osterwalders four different areas of the business model framework as described in section 3.3, being product, customer interface, infrastructure management and financial aspects.

5.3.1 Product

The product area describes the business the company is in, the products it offers and the value propositions offered.

Of the organizations that participated in the survey several only deal with pico solar products. Others offer broader ranges of solar products including larger solar home systems, solar water boilers and solar back-up systems for grid connected households that offer electricity in case of a black out.

[3] J. Perkins. (2006). *Confessions of an Economic Hit Man*. Ebury Press.

Three survey participants also offer products that are not solar related. Interviewee 004 doesn't even offer any solar products in Kenya at all (at the time the interview took place). While the company had tested solar charging for their lights they found charging by a human powered cycle, similar to a home trainer to be a much more efficient way of charging lights. …

Interestingly there was a large difference in the number and variety of pico solar products the interviewed companies were dealing with. Five just focused on one single product, being a solar lantern or task light with the occasional opportunity of mobile phone charging, while the others were offering a broader range of products ranging from small task lights to small home systems with up to 4 lights.

The prices for products offered by the respondents falling within the same categories, were found to be comparable. An exception were the prices charged by 005, but as the interviewee mentioned, these prices reflect the true quality of the products it offers, which are of a much higher standard than offered by its competitors.

As many poor households own one or sometimes several mobile phones, phone charging is very important. For this reason most solar lighting products also offer the option of charging a mobile phone directly off the solar panel or off the battery that feeds the light. By adding this feature pico solar products become a more valuable product than when they are only able to provide light. Interviewee 002: "Phone charging significantly adds to the quality of life of people in the rural areas. It's way more important than light."

The most drastic form of business model innovation with regards to the product is put forward by 004. The company tested its solar charging model and found out that solar charging was far less efficient than charging lights with a charger that resembles a home trainer. By pedalling on the so-called POWERCycle, an entrepreneur is able to charge 5 lights in 30 minutes of cycling. The company decided to not offer its solar charging products in Kenya, but instead focus on charging with the POWERCycle.

5.3.2 Customer interface

All respondents target the same customers, being the poor households in Kenya without grid access. These customers can also be referred to as BOP customers. As we've seen in the previous paragraph, some companies have a broader product range than others. This results in the fact that these organizations target the whole spectrum of BOP customers - which is not entirely homogeneous, as we've acknowledged in 3.2 - ranging from the top to the bottom of the BOP.

There are several ways the products reach the end-consumers. The for profit participants to the interview all sell a small fraction of their products directly to end-consumers, while the majority of sales is through local retailers. Besides selling directly or through local retailers the companies also sell to NGO's, MFI's and Community Based Organizations (CBO's), who themselves deliver the products to the end-consumers at full price, partially subsidized or for free. Some interviewees were sceptical about NGO cooperation. Interviewee 005: "We believe in a full commercial model, but we're willing to cooperate with NGO's. At the end it appears these models are not sustainable, so we prefer to go the full commercial route." Interviewee 002: " NGO's take a lo of time, business goes a lot faster."

Interviewee 003 has performed testing on selling its products using a "kind of Tupperware model", where a local entrepreneur invites people to a product demonstration and tries to sell the products to the attendants receiving a commission for every product sold. A similar initiative was initiated by interviewee 008. The company employs so called "foot soldiers" that work on a commission basis and sell products in a certain area by going into the field instead of selling in a retail outlet: The advantage for us is that the foot soldiers are likely to speak the same language as the people, they know the terrain and the potentiality of the region they work in."

5.3.3 Infrastructure management

The infrastructure management looks at how the company performs infrastructural or logistical issues, with whom, and as what kind of network enterprise. Figure 6 shows the outline of a typical supply chain for pico solar products.

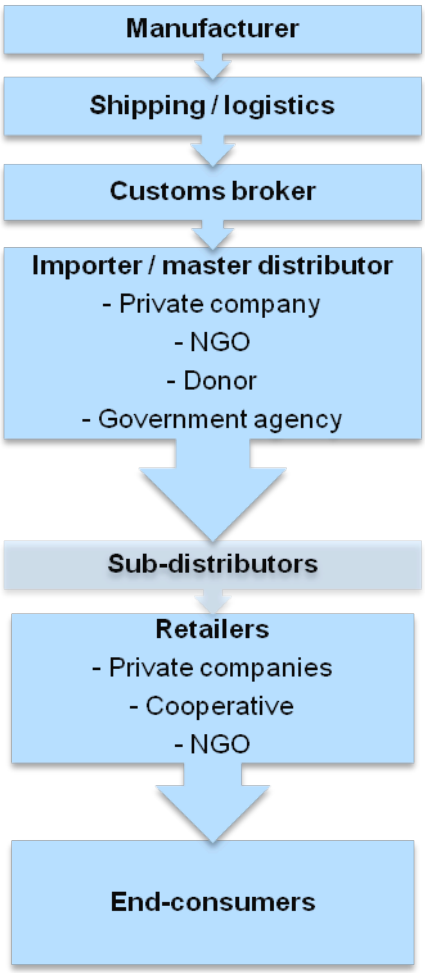

Figure 6: Typical supply chain for pico solar products (adapted from GTZ, 2010).

Ten respondents import finished products that are manufactured in Asia. Three organizations import parts and assemble them locally into finished products. All imported goods enter the country through the port of Mombasa. From there all respondents ship the products to Nairobi, which serves as a hub for further distribution. There are various ways in which the distribution from this part in the supply chain towards the end-consumer takes place.

Several interviewees have entered into partnerships with logistical companies for the transportation of their products from Nairobi to the retailers and end-consumers. 001 uses a courier service: “When our distributors want to order something we send it directly to the dealer through the courier service and from thereon they choose their own way to distribute to the end-users.” Interviewee 008, selling a whole range of products including several pico solar products from other manufacturers: “ We use a milk run model.[4] As our products are going to a certain region we also send pico solar products and (larger) panels in the same delivery.” Hereby the transportation costs are distributed over more products so delivery costs are lower than they would be if only pico solar products were transported in the delivery.

[4] Milk run is a term used in logistics for a delivery run mixing different products from different suppliers.

The Tupperware and foot soldier sales models discussed in the previous section are also an innovative way of serving areas that are harder to reach for traditional distribution.

5.3.4 Financial aspects

The financial aspects area of the business model describes the revenue model, the cost structure and the business model's sustainability.

Interviewees 001 through 010 are all for profit organizations, which means they all intend to make money by selling their products, be it directly to end-consumers or to local retailers, NGO's, MFI's or CBO's. As the products tend to have a long life expectancy and have been recently introduced there is not a large market for spare parts and these do currently not deliver a significant contribution to the revenues. While some interviewees offer a system that can charge several lights at the same time as we've seen in 5.2.1, none of them offer these charging services themselves.

Interviewee 006 experiments in selling its lights to the employees of large companies. "We go to institutions like coffee and flower plantations that have a big group of employees that don't have electricity." The employees get a loan from their employer and pay for the lights in instalments by a small amount that is withheld from their monthly wages.

Interviewee 011 represents an NGO that has a model that is very interesting to mention, although it is not a commercial revenue model. The organization hands out solar lanterns for free in pre-selected local communities. The recipients do not pay for the ownership of the lanterns, but pay a monthly fee to the NGO that is similar to or slightly lower than the money they would otherwise be spending on kerosene for lighting. This money is set aside by the NGO to be invested in community projects that are chosen by the local communities. These projects contribute to the economical development of the communities.

5.4 Carbon finance considerations

In the initial research and outline of the semi-structured interview the subject of carbon finance was not included. During the first interviews conducted in Kenya and at the Lighting Africa conference it became apparent that this topic was of interest to the interviewees and other stakeholders in the off-grid solar market. Therefore the topic was later on included in the semi-structured interview outline and interviewees were asked whether they were familiar with carbon credits.

Two interviewees were not questioned on the matter, six were familiar with the concept of carbon credits and five were not. Out of these five only two were applying for carbon credits or had done so in the past. One of these, the commercial company 002, has applied for CDM credits for its operations in India and is starting to sell voluntary credits under the gold standard for several countries including Kenya.

While only two interviewees were already working with carbon credits several others were very interested in the potential benefits carbon credits could bring to their organization. 005 mentioned to be preparing for a carbon credit application by storing the GPS coordinates and pictures of the houses of its customers.

On the other hand interviewee 009 states it is too difficult for his company to apply for carbon credits: "The whole process is toot tedious. Tracing the customers we're dealing with and quantifying the savings is difficult." Interviewee 012 is an NGO and has applied for CDM credits, but its experience with the whole process is not very positive as a large amount of time was spent for a very small pay out.

The international market for carbon credits arises from the Kyoto Protocol that has set binding targets for the reduction of greenhouse gas emissions for 37 industrialized countries and the European Community. The CDM is one of the market-based mechanisms included in the Kyoto Protocol that helps countries meet their emissions targets while involving developing countries in this process (UNFCCC, 2010).

Successful CDM projects have mainly been larger scale power production systems, while only a few small-scale energy projects have been implemented under CDM (Mills 2010). Off these there are only two projects that promote off-grid solar lighting in the developing world (CDM 2008 and 2009). The reason that there are so few off-grid lighting CDM projects lies in the fact that the whole application process is very time-consuming and the transaction costs are high. Taking this into consideration the Small Scale Working Group of the CDM Executive Board (SSC WG) has been mandated to improve the methodologies for small-scale projects. In May 2010 the SSC WG invited the public to give inputs on a methodology framework in order to estimate greenhouse gas emissions from replacing fuel –based lighting with LED lighting systems (UNFCCC, 2010).

Carbon credits could become a very interesting opportunity for the pico solar sector to decrease its prices as the carbon credits could be used as a subsidy to their products. If a proper evaluation method is designed the actual value of carbon credits for each independent product depends on the characteristics of the design of the evaluation method that assesses the decrease of CO_2 emissions for each product and the market value of carbon credits. Mills (2010) estimates that the value of carbon offsets could approach the cost of a solar lantern.

The uncertainty that currently still surrounds carbon credits for off-grid solar lighting solutions attracts companies that try to bank on this uncertainty. Interviewee 002: “Companies get approached by carbon credit financing agencies that want to buy their supposed future credits at a throwaway price. They’re not sure whether they come through at all, but they get for example 25% of what they might get so that serves them in the venture capital that is lacking”

5.5 Field work observations

Mobile phones have been an enormous success in Kenya and other developing countries. Virtually everybody seems to own a mobile phone at present. As the grid connectivity rate is low, millions of people are not able to charge their mobile phones at home, but rely on charging stations run by entrepreneurs, who charge a fee per full charge. Several pico solar products offer the opportunity of charging a mobile phone directly from the solar panel or from a battery charged by the panel. A number of interviewees stated that for a large amount of customers the feature of phone charging is more important when buying a pico solar product than lighting. Interviewee 002: “Phone charging significantly adds to the quality of life of people in the rural areas. It’s way more important than light.”

During the fieldwork period in Nairobi we visited the largest slum called Kibera. In our tour we only came across one shop selling solar lighting product and this store was run by a British NGO. One other small store had a large poster of solar lanterns on its door. When the storeowner was asked how his sales of these products were he replied that he stopped selling the lanterns as they were too expensive and he therefore didn’t get enough customers for it. While solar lighting products were thus hard to find we passed numerous stores selling kerosene.

Without judging whether this is a good or a bad thing it was remarkable to see that there are many people from developed countries working in the higher positions at companies selling solar products in Africa. This was especially striking at the Lighting Africa Outstanding Product Award Ceremony, where the whole stage of award winners was filled with people from developed countries.

5.6 Conclusion

The four main challenges that companies and NGO's offering pico solar products face in growing their operations are affordability, poor quality products, consumer awareness and distribution. These challenges are closely linked to the constraints of the BOP business environment that were mentioned in 3.3.

The interviewees have various ways in which they have designed their business models in order to adapt to the challenges faced and the BOP market in general. The business models are not static but regularly revised and the interviewees experiment with new product designs, partnerships, methods of delivery and credit schemes for consumers.

Carbon credits could help lower the prices of pico solar products, but there is still a lot of uncertainty surrounding the application and validation process. The UNFCCC is studying how to overcome these difficulties so hopefully this will result in a financial incentive to reduce the price of pico solar products and consequently a rise in sales volumes in the near future.

6 Recommendations

This research has identified several challenges faced by companies and NGO's in the pico solar industry in Kenya. As the shift from kerosene to solar lighting contributes to the development of poor households DGIS is interested to find out in what way it could facilitate this transition. Therefore further extensive research needs to be conducted into the way in which the challenges can be confronted and what role DGIS could play in this process. The results of this research could assist in the exploration of these opportunities:

The affordability of pico solar products for BOP customers could for example be improved by a clear accessible application and registration processes of carbon credits for pico solar products. Another option would be to investigate innovative ways like loan bundling in which consumers could access credit which is difficult as the loan amounts for pico solar products are too small for MFI's.

Poor quality products can be prevented to enter and spoil the market by a well designed system of quality standards. These standards should at the same time be enforced in order to be effective, which in a country like Kenya might appear to be challenging.

Consumer awareness of the existence and benefits of pico solar products could be increased by information campaigns and product demonstrations.

The challenge of distribution will probably be the hardest challenge for an industry wide solution to be developed. As logistical issues solutions need to be addressed at the organizational level and infrastructural issues are extremely costly to solve.

When studying the potential ways in which the pico solar market can be assisted, DGIS should investigate what the expected effects of the potential policies would be and at which costs this can be achieved.

References

Adkins, E., Eapen, S., Kaluwile, F. Nair, G., Modi, V., (2010). Off-grid energy services for the poor: Introducing LED lighting in the Millenium Villages Project in Malawi. *Energy Policy 38* p. 1087-1097.

Afuah, A. and C. Tucci (2003). Internet Business Models and Strategies. Boston, McGraw Hill.

Barnes, D. and Foley, G. (2004). Rural Electrification in de Developing World: A Summary of Lessons from Successful Programs. World Bank, Washington DC.

CDM. 2008. Clean Development Mechanism Project Design Document – d. Light Rural Lighting Project, Version 2, 13/10/2008.

CDM. 2009. Clean Development Mechanism Project Design Document - Rural Education for Development Society (REDS) CDM Photovoltaic Lighting Project, Version 4, 4-Aug-09.

The Economist (2008). The World in Figures: Countries. *The World in 2008*. p. 114.

Energy Act (2006). Energy Regulatory Commission, Kenya. http://www.erc.go.ke/energy.pdf (last retrieved August 6th 2010).

Irvine-Halliday, D., Peon, R., Platonova, I. (2005) Solid State Lighting, http://www.lutw.org/files/4.10_Solid_State_Lighting_in_Renewable_Energy_Solutions_Handbook_ITU-D_2005.pdf (last retrieved September 27th 2010).

GTZ (2009). Target Market Analysis: Kenya's Solar Energy Market. http://www.gtz.de/de/dokumente/gtz2009-en-targetmarketanalysis-solar-kenya.pdf (last retreived July 6th 2010).

International Energy Agency (2009,1). Electrification Rates in Selected Regions, IEA Electricity Database 2009. http://www.iea.org/weo/database_electricity/electricity_access_database.htm (last retrieved June 22nd 2010).

International Energy Agency (2009,2). World Energy Outlook, Paris.

Jaiswal, A.K. (2007). Fortune at the Bottom of the Pyramid: An Alternate Perspective. *Indian Institute of Management. Working Paper No. 2007-07-13*.

Johnstone, P. (2009). Self-reported Impacts of LED Lighting Technology Compared to Fuel-based Lighting on Night Market Business Prosperity in Kenya. *Lawrence Berkeley National Laboratoy. LBNL Paper LBNL-2076E*. http:// www.escholarship.org/uc/item/46r3s4vv. (last retrieved June 16th 2010).

Karamchandani, A., Kubzansky, M., Frandano, P. (2009). Emerging Markets, Emerging Models. *Monitor Group*, Cambridge MA.

Karnani, A. (2007). Mirage at the Bottom of the Pyramid, How the private sector can help alleviate poverty. Working Paper, Stephen M. Ross School of Business, University of Michigan, April.

Linder, J. and Cantrell S. (2000). Changing Business Models: Surveying the Landscape, accenture Institute for Strategic Change.

London, T. (2007). A Base-of-the-Pyramid Perspective on Poverty Alleviation. *William Davidson Institute, Working Paper*.

Mills, E. (2010). From Carbon to Light, A New Framework for Estimating Greenhouse-Gas Reductions from Replacing Fuel-based Lighting with LED Systems. The Lumina Project,

Technical Report #5. http://light.lbl.gov/pubs/tr/lumina-tr5-lores.pdf (last retrieved September 18th 2010).

Nassiuma, D. (2005). The 2004/05 Kenya Integrated Household Budget Survey (KIHBS), Padi Workshop Presentation. http://www.worldbank.org/afr/padi/KIHBS_Nassiuma.pdf (last retrieved August 24th 2010).

Nieuwenhout, F.D.J., Van Dijk, A., Lasschuit, P.E., Van Roekel, G., Van Dijk, V.A.P., Hirsch, D., Arriza, H., Hankins, M. and Wade, H. (2001). Experience with Solar Home Systems in Developing Countries: A Review. *Progress in Photovoltaics: Research and Applications; 9: 455-474.*

Obeng, G.Y., Akuffo, F.O., Braimah, I., Evers, Hans-Dieter, Mensah, E. (2008). Impact of solar photovoltaic lighting on indoor air smoke in off-grid rural Ghana. *Energy for Sustainable Development, Volume XII No.1*.

Peon, R., Doluweera, G., Platonova, I., Irvine-Halliday, D., Irvine-Halliday, G. (2005). Solid State Lighting for the Developing World – The Only Solution. *Optics & Photonics 2005, Proceedings of SPIE*, Vol. 5941, pp. 109-123.

Peterovic, O., C. Kittl, et al. (2001). Developing Business Models for eBusiness. International Conference on Electronic Commerce 2001, Vienna.

Prahalad, C.K. (2004). *The Fortune at the Bottom of the Pyramid: Eradicating Poverty Through Profits*. Upper Saddle River, NJ: Wharton School Publishing.

Radecsky, K. (2009). Solid-State Lighting on a Shoestring Budget: The Economics of Off-Grid Lighting for Small Businesses in Kenya. *Lawrence Berkeley National Laboratory. BBNL-2075E*. http://www.escholarship.org/uc/item/2714q6kz. (last retrieved June 16th 2010).

REN21 (2008). Renewables 2007 Global Status Report. *Paris: REN21 Secretariat and Washington, DC: World Watch Institute*.

Rural Electrification Authority (2008). Strategic Plan for the Period 2008-2012. http://www.rea.co.ke/index.php?option=com_docman&task=cat_view&gid=31&Itemid=54 (last retrieved April 20th 2010)

Shafer, S.M., Smith, H.J., Linder, J.C. (2005). The Power of Business Models. *Business Horizons 2005*, 48, pp. 199-207.

Stähler, P. (2002). Business Models as an Unit of Analysis for Strategizing. International Workshop on Business Models, Lausanne, Switzerland.

UNDP. (2005). Energizing the Millennium Development Goals. A Guide to Energy's Role in Reducing Poverty. New York, NY.

UNDP. (2008). Creating Value for All: Strategies for Doing Business with the Poor. New York, NY.

UNFCCC. (2010). Considerations of Potential Fossil Fuel Lighting Replacement Methodology. SSC WG Twenty-fifth meeting Report Annex 13.

Wamukonya, N. (2007). Solar home system electrification as a viable technology option for Africa's development. *Energy Policy 35: 6-14.*

World Resources Institute. (2007). The Next 4 Billion. http://pdf.wri.org/n4b_full_text_lowrez.pdf (last retrieved August 29th 2010)

Appendix A: Access to energy and the MDG's

MDG	Energy Linkages
1 Eradicate extreme poverty and hunger	The availability of energy such as electricity and fuels are essential to generate jobs, industrial activities, transportation, commerce, micro-enterprises, and agriculture outputs. Energy plays an important role the production of food, but also in the processing, conservation and cooking.
2 Achieve universal primary education	Access to electricity allows children to study after dark. To attract teachers to rural areas electricity is needed for homes and schools. After dusk study requires illumination. Many children, especially girls, do not attend primary schools in order to carry wood and water to meet family needs.
3 Promote gender equality and empower women	Lack of access to modern fuels and electricity contributes to gender inequality. Women are responsible for most household cooking activities and the collection of the fuels necessary for these activities. These tasks take time away from other productive activities as well as from educational and social participation. Access to modern energy sources eases women's domestic burden and allows them to pursue educational, economic, and other opportunities.
4 Reduce child mortality	Respiratory illness caused by indoor air pollution from traditional fuels and stoves, directly contributes to child disease and mortality. The consumption of unboiled water also causes diseases.
5 Improve maternal health	Women are disproportionately affected by indoor air pollution caused by the burning of fuel wood, charcoal and kerosene. Lack of electricity in health clinics and lack of illumination for nighttime deliveries results in poor conditions for giving birth. The physical burden of fuel collection and transport furthermore contribute to poor maternal health conditions, especially in rural areas.
6 Combat HIV/AIDS, malaria, and other diseases	Radio and television, that require electricity can spread important public health information to combat deadly diseases. Health care facilities, doctors, and nurses, all require electricity and the services that it provides (illumination, refrigeration, sterilization, etc.) to deliver effective health services.
7 Ensure environmental sustainability	Energy production, distribution, and consumption has many adverse effects on the local, regional, and global environment; these effects include indoor, local, and regional air pollution; local particulates; land degradation; acidification of land and water; and climate change. Cleaner energy systems are needed to address all of these effects and to contribute to environmental sustainability.
8 Develop a global partnership for development	Partnerships between development agencies, civil society, and the public and private sector can support sustainable development, including the delivery of affordable, reliable, and environmentally sustainable energy.

Adapted from UNDP, 2005.

Appendix B: Outline semi-structured interview

First introduce the research depending on the amount of knowledge about it with the interviewee

As some questions could involve sensitive information a company is not willing to share it should be clearly mentioned in the introduction that you are aware of this and that the interviewee should feel free to abstain from answering in such case.

General

This part of the interview focuses on the activities of the organization.

- What products does the company sell? Renewable energy, other?
- What is the average price for end-consumers of the solar products?
- For how long has the company been selling solar products? (In Kenya and elsewhere)
- Where is the company geographically operating offering solar products?
- What is the yearly turnover in Kenya? Or how many units of solar lanterns/ home systems do you (expect to) sell?
- What percentage of the turnover comes from solar products?

Business model and partners

This part of the interview focuses on the way the company actually conducts its business and whom it partners with in the process.

- What does the business model look like? (Partners / alliances etc.)
- How are retailers selected?
- Do you work with MFI's?
- Do you work with NGO's?

- Do you work with the (local) government?

- Do you provide a package of a large solar panel with several lamps to entrepreneurs who can sell the lamps and then charge them for a fee? If not what do you think of this idea?

- Do you perform "peripheral" business support activities for retailers (ie business plan support, finance, marketing, training etc)?

- Have you made any significant modifications to your business model?

- Are you familiar with carbon credits and the Clean Development Mechanism (CDM)?[5]

- Does your company (plan to) apply for carbon credits?

Challenges

This part focuses on the challenges face by the company. Hereunder several potential challenges are mentioned, but the interview shouldn't focus only on these, but should leave room for the interviewee to come up with other challenges as well.

- Poor quality products?

  ⇒ Reputational damage for solar?

  ⇒ Competition selling at low price?

- Lack of customers who are able to afford products?

- Lack of access to credit to upscale company?

  ⇒ Hard to get a loan from a bank?

  ⇒ Hard to find investors?

- Difficulties in distribution?

- Lack of potential retailers?

[5] This and the following question were not included in the first four interviews, but added later on as there appeared to be significant interest in this subject amongst interviewees and during the Lighting Africa conference.

⇒ Lack of interest in solar?

⇒ Lack of knowledge about solar?

⇒ Lack of technical knowledge?

⇒ Lack of financial capacity?

Appendix C: Characteristics of interviewees

Interviewee	001	002	003	004	005	006	007	008	009	010	011	012	013
Type	C	C	C	C	C	C	C	C	C	C	N	N	N
Operations	M	M	M	M	M	D	D	D	M/D	M/D	M/D	M/D	M
Geographical operations	K, Af, As	K, Af, As	K, Af, As	K, Af, As	K, Af, As	K	K	K	K, Af	K	K	K, Af, S	K
Operating since (Kenya, worldwide)	2009, 2005	2010, 2007	2010, 2008	2010, 2010	1997, 1995	2010, x	2010, x	1999, x	1983, x	2003, x	2005, x	2006, 2006	2008, x
Product range	P	P	P	O	P,L	P	P,L	P,L, O	P,L	P,L	P	P,L	P,O
Price range	14-98	14-50	17	6	80-320	25	43-80	17-100	12-300	n.a.	33-300	14-100	35
MFI cooperation	0	+	+	+	0	+	-	+	+	-	+	+	-
NGO cooperation	+	0	+	+	-	0	-	+	-	+	+	+	+
Charging station	0	-	-	+	-	+	-	-	-	+	-	-	-
Imported goods	F	F	F	F	F	F	P	F	F	F	P	F	P
Familiar with carbon credits	+	+	n.a.	n.a.	+	+	-	-	+	-	-	+	-
Applying for carbon credits	-	+	n.a.	n.a.	0	-	-	-	-	-	-	+	-

Table X: Characteristics of interviewees

Legend:

- Type: C = Company; N = NGO
- Operations: M = Manufacturer; D = Distributor
- Geographical operations: K = Kenya; Af = Other Africal countries; As = Asia; S = South America
- Product range:
- Price range: price range of all pico solar products in $US
- + = Yes; 0 = Working on it; - = No; n.a. = Information not available
- Imported goods: F = finished goods; P = parts